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Pre-Season 2003 Stock Size Forecasts For Skeena River and Nass River Sockeye Salmon

Prévisions pré-saison de la taille des stocks de saumon rouge des rivières Skeena et Nass en 2003

Steven Cox-Rogers

Fisheries and Oceans Canada
Stock Assessment, Science Branch
417 – 2nd Avenue West
Prince Rupert BC V8J 1G8

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Abstract

This working paper presents pre-season forecasts for Skeena River and Nass River sockeye returning in 2003. The basic forecasts developed in this working paper are all based on procedures that performed best in past assessments (Wood et al 1995, 1996). Three forecasting models are used to forecast Skeena sockeye returns in 2003, and two forecasting models are used to forecast Nass sockeye returns in 2003. The pre-season forecasts indicate a low return of Skeena River sockeye and an average return of Nass River sockeye can be expected for 2003. For the Skeena River sockeye return in 2003, the recommended median (50%) forecast is the sibling model estimate of 1,205,331. For the Nass River sockeye return in 2003, the recommended median (50%) forecast is the 5yr average model estimate of 764,183 although the potential for a larger median return of 867,000 (to Canada) should be recognized as suggested by the Nisga'a Fisheries analysis. Actual 2003 returns will need to be assessed in-season.

Résumé

Ce document de travail présente les prévisions pré-saison de la remonte du saumon rouge dans les rivières Skeena et Nass en 2003. Les prévisions de base obtenues dans ce document sont basés sur les procédures qui ont donné les meilleurs résultats dans les évaluations passées (Wood *et al.*, 1995 et 1996). Trois modèles sont utilisés pour prévoir la remonte dans la rivière Skeena en 2003, et deux modèles sont utilisés pour prévoir la remonte dans la rivière Nass en 2003. Selon les prévisions, on peut s'attendre à une faible remonte de saumon rouge dans la rivière Skeena et à une remonte moyenne du saumon rouge dans la rivière Nass en 2003. La prévision médiane (50 %) recommandée pour la remonte du saumon rouge dans la rivière Skeena en 2003 est l'estimation de 1 205 331 poissons obtenue par le modèle des germains. La prévision médiane (50 %) recommandée pour la remonte du saumon rouge dans la rivière Nass en 2003 est l'estimation de 764 183 poissons obtenue par le modèle de la moyenne quinquennale, bien qu'il faille reconnaître la possibilité d'une remonte médiane plus élevée, soit de 867 000 poissons (au Canada), tel que suggéré par l'analyse des pêches Nisga'a. Les remontes réelles de 2003 devront être évaluées au cours de la saison.

1.0 INTRODUCTION

Run size forecasting is an important component of the management process for Skeena River (Area 4) and Nass River (Area 3) sockeye salmon. Two types of forecasts are used: a) pre-season estimates of total return, and b) in-season estimates of total return. Pre-season forecasts are generated well in advance of the fishing season, and are primarily used for expectation and planning purposes. In-season forecasts are generated during the fishing season, are based on actual return-year data, and are used for active management of the fishery (Cox-Rogers 1997). Of the two forecast types, the in-season estimates are the most important for management as they determine the number of salmon actually available for harvest. Pre-season forecasts provide general expectations, but are not used for active management of the Area 3 or 4 fisheries.

Pre-season forecasts for Skeena River and Nass River sockeye are generated from simple methods assessed and recommended in previous working papers (Wood et al 1995, 1996). The forecasting process is based on three guiding principles (Rutherford and Wood 2000). First, the stocks being forecasted must be measurable. That is, forecasts should not be attempted where stock size cannot be measured with reasonable accuracy. Second, the forecasts should specify the probability of all possible run sizes, not just the point estimate. Third, the forecasts should be selected for their predictive power measured in retrospective analysis, not on how well the underlying models fit the historical data.

This working paper presents pre-season forecasts for Skeena River and Nass River sockeye returning in 2003. The basic forecasts developed in this working paper are all based on procedures that performed best in past assessments (Wood et al 1995, 1996). Three forecasting models are used to forecast Skeena sockeye returns in 2003, and two forecasting models are used to forecast Nass sockeye returns in 2003.

2.0 METHODS

2.1 Data Sources

All data used to generate and evaluate the Skeena River and Nass River sockeye forecasts in this working paper are compiled in the Appendix Tables. Total stock and escapement data for Skeena River (Area 4) and Nass River (Area 3) from 1970-2002 were compiled by the responsible manager (M. Potyrela, DFO, Prince Rupert, B.C. pers. comm.). These data include reconstructed catches of Skeena and Nass sockeye salmon in mixed-stock fisheries in Alaska and northern British Columbia, based on stock reconstructions for 1982-1992 reported by Gazey and English (1996) and stock composition estimates for 1982-1983 from a joint Canada-U.S. tagging study. An updated revision to Gazey and English (1996) is expected in 2003. As the revision will change some of the data reported in

Appendix Tables 1-4, the data used in this working paper should be considered interim until the revision is completed. Sockeye smolt abundance data are from Wood et al (1998) and unpublished data on file with the primary author in Prince Rupert.

Except where noted, the annual production data used in this working paper are all aligned according to brood year and subsequent production (TOTAL RETURN) by brood year. Skeena and Nass River sockeye predominantly return as three-year olds (age 3-2), four-year olds (age 4-2), or five-year olds (age 5-2 or 5-3). Six-year old sockeye (age 6-3) are found in the Nass River. For reference purposes, the following table summarizes the principle brood years and return years for sockeye salmon contributing to the 2003 Skeena River and Nass River returns.

		Return Year		
Brood year	**Smolt Year**	**Age 3**	**Age 4**	**Age 5**
1998	**2000**	**2001**	**2002**	**2003**
1999	**2001**	**2002**	**2003**	**2004**
2000	**2002**	**2003**	**2004**	**2005**

2.2 Forecasting Models

The forecasting models used in this working paper follow the methodology of Wood et al (1995). Of the ten models considered by Wood et al (1995) **three** are used in this working paper (e.g. the same as used by Rutherford and Wood 2000, Wood et al 1999, and Cox-Rogers 2001, 2002). A fourth model (Bayesian Composite) was developed previously (Cox-Rogers 2001) but was not endorsed by PSARC. All models assume log-normal error structure as generally recommended for these types of analyses (Hiborn and Walters 1992). Model parameters were estimated using SYSTAT (Wilkinson 1990).

-Forecast Model A: the five-year average model

For both Skeena River and Nass River sockeye, the first model used to forecast 2003 returns was the simple five-year average return by calendar year model (previously labeled 5YAVGCY, Wood et al. 1995). This model has previously been endorsed by PSARC because it performed as well as the competing models and was rated best for sockeye stocks under the root mean square error (RMSE) criterion that they concluded to be most important. A practical advantage of the five-year average stock size model is that no biological assumptions, understanding, or sampling data are required beyond the record of numerical abundance each year (Rutherford and Wood 2000). This model assumes the near future will be similar to the recent past.

The five-year average return by calendar year model is given by:

$$\ln(N_{t+1}) = a + \varepsilon_t$$

where N_t is total stocks size in year t, ε_t is a normal variant with mean 0 and variance σ^2, and a is the most recent 5-yr calendar average = $\sum \ln(N_i)/5$ for $i = t-4$ to t.

-Forecast Model B: the smolt model

Two biological models were used to forecast Skeena River sockeye returns in 2003. The first biological model is a non-linear stock-recruitment relationship based on observed smolt production:

$$\ln(R_t) = a + b\ln(J_t) + \varepsilon$$

where R_t is the adult return and J_t is the smolt abundance for brood year t.

The forecast adult return from smolts of brood year 1998 (source of 2003 age 5-2 returns) and the forecast adult returns from smolts of brood year 1999 (source of 2003 age 4-2 returns) were combined as per Wood et al (1998) to produce the total forecast age 4-2 and age 5-2 return for 2003. Here, the long-term average proportion of age 3-2 (6.7%) age 4-2 (43.7%) and age 5-2 (49.6%) in the adult returns was used to apportion the forecast returns from each brood year. As a simple approximation, the standard deviation for the combined estimate was assumed to be the maximum value associated with the two return forecasts, given that both were very similar.

-Forecast Model C: the sibling model

The second biological model used to forecast Skeena sockeye is a non-linear sibling age-class model (Bocking and Peterman 1988) based on observed returns of a younger age class from the same brood year:

$$\ln(R_{t,k+1}) = a + b\ln(R_{t,k}) + \varepsilon$$

where $R_{t,k}$ is the adult return at age k in brood year t.

Two independent regression models for estimating 2003 returns were constructed for the sibling estimate: one relating age 4-2 to age 3-2 returns over the data series, and one relating age 5-2 to age 4-2 returns over the data series. The total 2003 age 4-2 and age 5-2 return was estimated as the simple combination (sum) of the two regression model forecasts as per Wood et al (1998). As a simple approximation, the standard deviation for the combined estimate was assumed to be the value associated with the regression model forecast contributing the most to the predicted total return in 2003 (e.g. age 5-2 vs. age 4-2 model).

For the 5-yr average model, means and standard deviations were computed from the most recent five years calendar return (1998-2002). For the regression-based smolt and
sibling models, means and standard deviations for the forecasted log-transformed stock sizes were computed as:

$$E[\ln(R_t)] = a + b\ln(X_{2001})$$

$$SD[\ln(R_t)] = s_{y \bullet x}\left\{\left(1 + 1/n + (X_{2001} - X_{mean})^2\right) / \sum (X_t - X_{mean})^2 \right\}^{.05}$$

where a and b are the regression parameters, $s_{y \bullet x}$ is the standard error of the estimate, X_{2001} is the independent variable (e.g. the number of smolts or returns for a sibling age class for the brood returning in 2003), X_{mean} is the average value of the independent variable, and n is the number of data points in the regression (Zar 1984).

2.3 Probability Distributions for 2003 Forecasts

As per previous PSARC working papers forecasting Skeena River and Nass River sockeye returns (Rutherford and Wood 2000, Cox-Rogers 2001, 2002), probability distributions for the each of the 2003 stock size forecast methods were computed by assuming that errors in the forecasted (log-transformed) stock size are normally distributed. Forecasted stock sizes in the log-transformed domain corresponding to probability reference points of 95%, 90%, 75%, 50%, 25%, and 5% were computed from the Student's t inverse distribution function (TIF) in SYSTAT using sample means and standard deviations (SD). Forecasted stock sizes in the log-transformed domain were then transformed back to the arithmetic scale for each probability reference point.

Note that the term "probability reference point" as used in this working paper is actually 1-α, or the probability that the stock size will meet or exceed the forecast value, whereas α is the probability that the stock size will meet or be below the forecast value. Note also that the model (most likely) value in the log-transformed domain corresponds to the median (50%) value in the original arithmetic scale.

Cumulative probability (α) distribution plots showing the 75% and 50% probability reference points were also generated using data in the log-transformed domain.

3.0 RESULTS

3.1 Trends in Stock Size

Skeena River sockeye returns have been steadily increasing since enhancement began in the early 1970's. Average total returns were 2.0 million from 1970-79, 2.9 million from 1980-89, and 3.8 million from 1990-2000. During the 1990's, the range of returns was been quite broad (6.9 million in 1996 to a low of 0.8 million in 1998). Very strong returns were seen in 2000 (4.7million) and 2001 (4.6 million), but they declined to 1.5 million in 2002 as a result of expected reduced production of age 4 (1998 BY) and age 5 (1997 BY) sockeye (Cox-Rogers 2002). Since 1990, escapements have exceeded or met escapement targets (1.05 million) in all years except 1998, 1999, and 2002.

Sockeye production for the Nass River has been relatively stable over time, with total returns ranging from 500,000 to just under 1.0 million since the mid 1990's. Decade average returns were 0.5 million from 1970-79, 0.5 million from 1980-89, and just under 1.0 million from 1990-2000. Since 1990, escapements have generally met targets (200,000) in all years. The total return to the Nass River in 2002 was just over 1.0 million fish and escapement was double the target of 200,000.

3.2 Performance of the 2002 Skeena and Nass pre-season Sockeye Forecasts

Sockeye fry recruitment and smolt production in Babine Lake (Skeena River) was dramatically reduced by parasitic infections at the Babine Lake Development Project sites in brood years 1994 and 1995 (1996 and 1997 smolt production, Wood et al 1998). To be precautionary, and to include biological information relevant to those events, forecasts for Skeena River sockeye in 1998, 1999, 2000, 2001, and 2002 were based on smolt and sibling age-class models rather than the five year average stock size model previously recommended by PSARC (Rutherford and Wood 2000, Cox-Rogers 2002).

For 2002, a precautionary approach was again supported by PSARC and so the lower sibling model forecast of 1.19 million was endorsed over the higher sibling age-class model forecast of 1.76 million. Pre-season forecasts computed for the Skeena and Nass Rivers in 2002 prepared by Cox-Rogers (2002) are compared with actual returns in Table 1. For the Skeena, actual stock size in 2002 (1.5 million) was well below the median (50%) forecast provided by the 5yr average model (2.4 million, error = +57%), below the smolt model forecast (1.76 million, error = +17%), and above the sibling model forecast (1.19 million, error = -21%). While the actual stock size in 2002 was closest to the smolt model forecast, the

actual return was within the 90% confidence intervals for all of the forecasts considered for 2002.

For the Nass, actual stock size in 2002 (1.0 million) was well above the median (50%) forecast provided by the 5yr average model (685,513, error = -34%). However, the actual stock size in 2002 was within the 90% confidence intervals calculated about the recommended forecast for 2002. An independent sibling-model forecast of 2002 Nass sockeye returns to Canada (Nisga'a Fisheries c/o R. Alexander, LGL Limited, Sydney, B.C., pers comm.) was approximately 1.3 million, or +27% in error.

3.3 Forecasts for Skeena Sockeye in 2003

Adult sockeye returns to the Skeena in 2003 will be from the 1998 and 1999 brood years. Escapements in both brood years were below target at 525,000 and 624,000 respectively. Not surprisingly, smolt production for these brood years (smolts out in 2000 and 2001) were not high very good (25.6 million and 41.4 million respectively). Neither of the 1998 or 1999 brood years was affected by parasitic infections at the BLDP.

Preliminary in-season indications from the 2001 and 2002 fisheries were disappointing with respect to possible returns of adults in 2003 that one might expect from the 1998 and 1999 brood years. The low smolt output for the 1998 brood year did not produce many age 3-2 returns in 2001, nor many age 4-2 returns in 2002 (Appendix Table 2). This suggests relatively poor production from the 1998 brood year and the possibility of a low age 5-2 return in 2003. For the 1999 brood year, smolt output was slightly higher than in 1998, but very low numbers of age 3-2 returns were seen in 2002. This suggests the potential for poor age 4-2 returns in 2003.

Forecasts of Skeena River sockeye salmon in 2003 for the three alternative models are shown in Table 2. The parameter estimates for the sibling and smolt models are shown in Appendix 5. The 5yr average forecast model predicts the highest median return (2.56 million) while the smolt model and the sibling model essentially predict the same median returns (1.19 million and 1.20 million) respectively.

Which forecast is most appropriate for 2003? In past years, PSARC has endorsed those models that provide the most conservative estimates. For example, **in 2000** the sibling model forecast was endorsed because its predictions reflected the poor freshwater production from the 1995 brood year (2000 age 5-2 returns). As the sibling model also produced the lowest forecast for 2000, it was also deemed by PSARC to be consistent with the precautionary approach to fisheries management. **In 2001**, the same logic was applied (e.g. precautionary approach) and so the lower smolt model forecast was endorsed by PSARC. The smolt

model forecast of sockeye returns to the Skeena River in 2001 (2.8 million) was actually 39% too low (Cox-Rogers 2002).

In 2002, and to be precautionary, the sibling age-class forecast (1.19 million) was again endorsed by PSARC but for different reasons. First, the 2002 sibling age-class model was consistent with the observed poor returns of both age 3-2 and age 4-2 sockeye in 2001. Second, the smolt-model forecast (1.71 million) was driven by predicted high production (1.27 million) from 1997 brood year smolts (85.2 million) which did not actually materialize in either strong age 3-2 jacks in 2000 or strong age 4-2 adults in 2001. Third, the 5yr average model did not appear very realistic given that it was being influenced by the very high returns in 2000 and 2001 from the very productive 1996 brood year.

Given the production data at hand (Appendix Table 2) it's unlikely that large returns to the Skeena can be expected **in 2003**. The close agreement between the smolt-model forecast (1.19 million) and the sibling-model forecast (1.20 million) appears to confirm this. As the sibling model forecast is associated with tighter confidence limits, I recommend it be used as the 2003 Skeena River sockeye forecast.

3.4 Forecasts for Nass River Sockeye in 2003

Forecasts of Nass River sockeye salmon in 2003 are shown in Table 3. The 5yr average forecast model predicts a median stock size of 764,000 sockeye. No other formal forecast models were evaluated by DFO for Nass returns in 2003, although Nisga'a Fisheries (R. Alexander, LGL Ltd, pers comm) has provided estimates from a sibling age-class model for the Nass based on age 3-2/age 4-2 and age 4-2/age 5-2 relationships observed in the Nass River fishwheels. While preliminary at this time, the data predict a Nass return to Canada in 2003 of 867,000 sockeye (Table 3)

3.5 Recommended Forecast

Recommended pre-season stock size forecasts for the Skeena and Nass River sockeye returns in 2003 are summarized in Table 4 for four probability reference points. Actual stock sizes are predicted to exceed the median (50%) forecast reference point 50% of the time (1 time out of 2). For the Skeena River sockeye return in 2003, the recommended median (50%) forecast is the sibling model estimate of **1,205,331**. For the Nass River sockeye return in 2003, the recommended median (50%) forecast is the 5yr average model estimate of **764,183** although the potential for a larger median return of **867,000** (to Canada) should be recognized as suggested by the Nisga'a Fisheries analysis. The other reference points are provided to facilitate risk adverse management decisions (Rutherford and Wood 2000). Actual stock sizes are predicted to exceed the lowest (90%) reference point 9 times out of 10, to exceed the intermediate (75%) reference point 3 times out of 4, and to exceed the highest (25%) reference point 1

time out of 4. The full cumulative probability distributions for the 2003 Skeena River and Nass River returns are presented graphically in Figures 1 and 2 respectively.

4.0 DISCUSSION

The pre-season forecasts indicate a low return of Skeena River sockeye and an average return of Nass River sockeye can be expected for 2003. For the forecast methods considered in this paper, there is 90% probability that the Skeena returns in 2003 will at least meet or exceed forecast levels that are still well below the escapement target. For the recommended sibling model forecast, there is only a 50% probability that the run size will at least meet or exceed forecast levels that are basically the same as the escapement target. Actual 2003 returns will need to be assessed in-season.

Rutherford and Wood (2000) note that previous evaluations of forecasting performance for northern B.C salmon stocks demonstrated that simple average models can work as well or better than those incorporating biological data. However, awareness of production contrasts is important. For the Skeena, the known production problems for the 1994 and 1995 brood years suggested that the average model would not take the lowered production into account, and so the smolt and sibling models were favored for forecasting in 1998, 1999, 2000, and 2001 over the average model. Both the smolt and sibling year class models correctly predicted the low abundance of Skeena sockeye in 1998 and 1999 whereas the average model did not (Rutherford and Wood 2000). In 2000, sockeye returns to the Skeena were well above forecast, which the biological models (and the average model) were not able to predict. In 2001, returns were again well above forecast, which, in retrospect, the sibling age-class model was best able to predict. In 2002, returns were slightly above those predicted by the sibling model. Returns to the Nass in 2002 were above those forecast using the simple 5yr average model. Actual returns were within the 90% confidence intervals predicted about the forecasts for both systems.

Each year, the general utility of pre-season forecasts is discussed by PSARC. The general imprecision of pre-season forecasting for most B.C. salmon stocks is widely known and many analysts have questioned their actual utility as pre-season planning tools (Palermo et al. 2000). Wood et al. (1995 and 1996) note that forecasts are useful when they reduce uncertainty. Pre-season forecasting for Skeena and Nass River sockeye salmon cannot be considered very precise, and must be supplanted with in-season forecasts when fish actually return. For Skeena and Nass sockeye, the primary utility of the pre-season forecasts is to inform managers about general expected run status (e.g. below average, average, or above average) rather than specific or absolute run strength.

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Table 1. Summary of pre-season forecasts and actual returns for Skeena and Nass River sockeye salmon stock size for 2002.

Model	Median Forecast	Actual (1)	Forecast Error	Percent Error
SKEENA				
5-yr mean	2,360,866	1,501,003	859,863	57%
Smolt	1,758,479	1,501,003	257,476	17%
Sibling	1,187,453	1,501,003	-313,550	-21%
NASS				
5-yr mean	685,513	1,033,347	-347,834	-34%
Sibling (2)	1,275,823	1,002,811	273,012	27%

(1) preliminary pending updated run-reconstruction results
(2) Nisga'a Fisheries Estimate (return to Canada)

Table 2. Summary of pre-season forecasts for Skeena River sockeye salmon stock size in 2003 from three alternative models. The target escapement is 1,050,000 sockeye. The recommended forecast is the sibling estimate.

Model	Brood Year	Forecasts for reference probabilities (1) 5%	10%	25%	**50%**	75%	90%	95%
5-yr mean	All Combined	13,121,985	8,310,568	4,543,041	**2,581,976**	1,467,431	802,183	508,048
Smolt	1998				530,931			
	1999				661,579			
	1998+1999	4,317,493	3,213,582	1,996,326	**1,192,510**	712,348	442,522	329,376
Sibling	1998				908,964			
	1999				296,367			
	1998+1999	3,009,914	2,439,701	1,738,888	**1,205,331**	835,490	595,492	482,679

(1) probability (chance) that the actual stock size will meet or exceed the specified forecast

Table 3. Summary of pre-season forecasts for Nass River sockeye salmon stock size in 2003. The target escapement is 200,000.

	Brood			Forecasts for reference probabilities (1)				
Model	Year	5%	10%	25%	**50%**	75%	90%	95%
5-yr mean	All Combined	1,294,739	1,117,942	920,686	**767,772**	640,256	527,286	455,285
Sibling (2)	1998+1999 plus other ages				**867,458**			

(1) probability (chance) that the actual stock size will meet or exceed the specified forecast
(2) Nisga'a Fisheries Estimate (return to Canada)

Table 4. Recommended pre-season forecasts for Skeena River and Nass River sockeye salmon stock size in 2003.

	Escapement	Forecasts for reference probabilities (1)			
Stock	Target	25%	**50%**	75%	90%
Skeena	1,050,000	1,738,888	**1,205,331**	835,490	595,492
Nass	200,000	920,686	**767,772**	640,256	527,286
(2)			**867,458**		

(1) probability (chance) that the actual stock size will meet or exceed the specified forecast
(2) Nisga'a Fisheries Estimate (return to Canada)

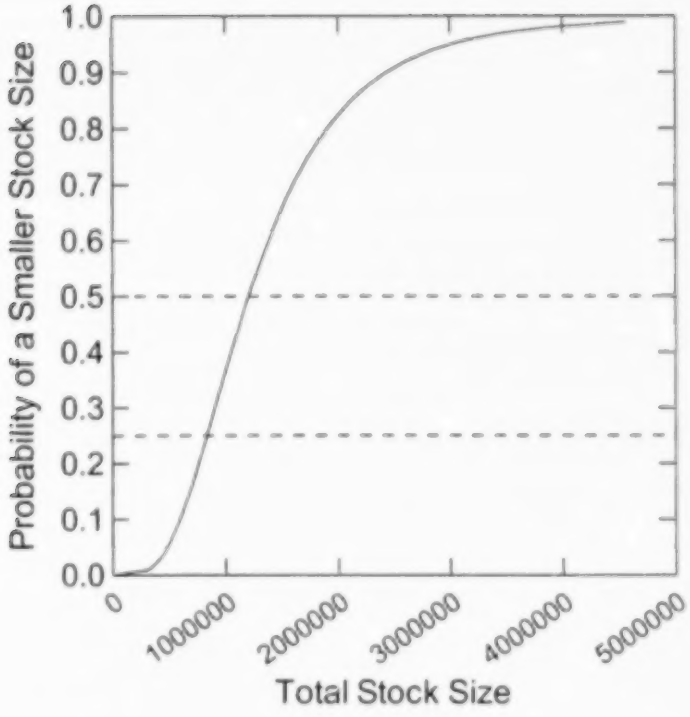

Figure 1. The forecasted cumulative probability distribution for total stock size in 2003 for **Skeena River** sockeye salmon. Also shown are the run sizes corresponding to the 75% (835,490) and median 50% (**1,205,331**) probability reference points.

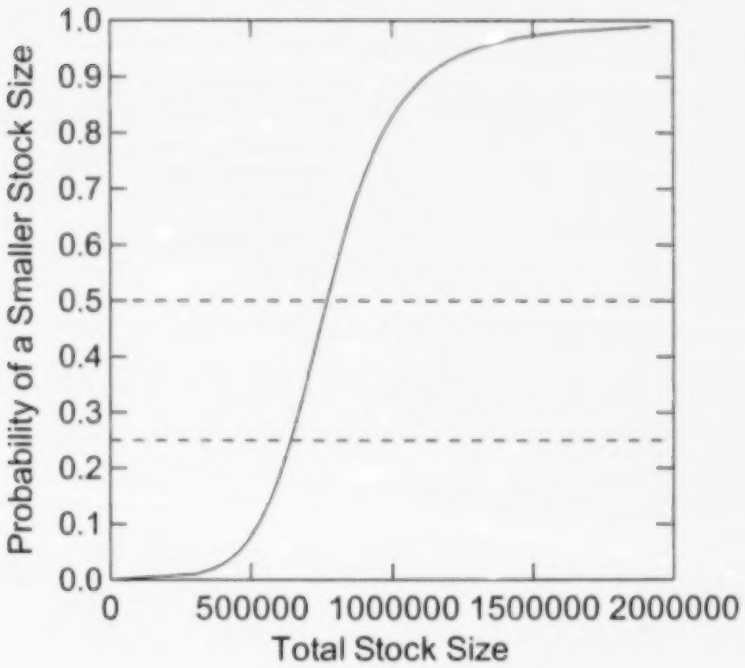

Figure 2. The forecasted cumulative probability distribution for total stock size in 2003 for **Nass River** sockeye salmon. Also shown are the run sizes corresponding to the 75% (640,256) and median 50% (**767,772**) probability reference points. The Nisga'a Fisheries estimate for Total Nass River sockeye Return to Canada is 867,458.

Appendix 1. Escapement, total stock size and age composition data for Area 4 (Skeena) sockeye salmon by calender year. Age 3 fish excluded (1)

YEAR	Escapement	Total Stock	Age Composition % age 4	% age 5	% other
1970	678652	1488730	62.3	30.5	7.2
1971	821850	1991109	56.9	38.3	4.8
1972	697237	1747489	24.2	71.0	4.8
1973	820196	2452004	47.1	43.2	9.7
1974	723898	2554843	32.6	63.8	3.6
1975	822633	1519339	74.2	24.0	1.8
1976	575590	1494668	36.4	61.5	2.1
1977	951805	2492902	45.3	51.8	2.9
1978	424075	1182541	22.3	73.0	4.7
1979	1166236	2924890	85.4	10.7	3.9
1980	542164	1476526	19.5	74.2	6.3
1981	1424509	3685964	86.3	11.2	2.5
1982	1140737	3763129	16.4	80.3	3.3
1983	893724	2047673	35.6	60.5	3.9
1984	1055215	2357385	60.8	32.9	6.3
1985	2174806	5164110	33.7	64.8	1.5
1986	716312	1773399	34.3	62.5	3.2
1987	1324128	2295489	42.2	54.6	3.2
1988	1417543	3885156	68.1	27.8	4.1
1989	1137994	2584137	33.5	62.4	4.1
1990	989566	2613624	31.1	61.9	7.0
1991	1232568	3514801	24.6	67.2	8.2
1992	1550109	4674458	38.5	45.1	6.4
1993	1629426	4875550	32.7	59.1	8.2
1994	1026816	2613270	24.1	68.7	7.3
1995	1720292	4972243	47.8	44.2	8.0
1996	1731058	6949067	53.7	39.7	6.5
1997	986912	3530600	21.7	68.7	9.6
1998	525194	1126060	6.1	86.6	7.3
1999	624366	830923	82.8	10.0	7.2
2000	1364000	4758229	86.2	12.1	1.7
2001	1538901	4589735	9.2	87.8	3.0
2002	630000	1501003	48.0	45.1	6.9

(1) note: subject to revised run-reconstructions now being completed, 2002 data are prel.

Appendix 2. Escapements, smolt production, and brood year returns by age class for Area 4 (Skeena) age 1.* sockeye salmon

Brood Year	Escapement	Smolts (a)	Adult Returns Age 3	Age 4	Age 5	Total
1970	634472	50.81	208350	832560	364351	1405260
1971	772539	105.24	256772	1127519	918877	2303168
1972	675623	106.20	137396	544756	1291903	1974055
1973	806171	38.10	255458	1129887	863534	2248878
1974	712822	45.62	47697	263423	313467	624587
1975	811034	64.72	296274	2498755	1095404	3890434
1976	559186	90.37	90509	288607	411933	791048
1977	925916	121.54	233886	3182751	3021288	6437926
1978	399648	57.51	155395	618162	1238674	2012230
1979	1123552	192.04	60223	729422	775824	1565469
1980	514459	136.57	353135	1432854	3346569	5132558
1981	1390891	146.25	120752	1740910	1108142	2969804
1982	1106173	94.61	66714	607723	1254186	1928623
1983	862265	49.84	88125	967641	1079371	2135137
1984	1007308	159.05	638641	2646485	1611282	4896408
1985	2149796	125.63	77631	866353	1616827	2560811
1986	689522	82.34	122711	814116	2361087	3297914
1987	1285861		89631	865543	2109589	3064763
1988	1366228	68.84	416049	1797485	2882665	5096198
1989	1095433	53.39	258240	1593694	1795016	3646951
1990	913172	99.65	90580	628574	2196606	2915760
1991	1132114	83.10	320804	2377904	2761171	5459879
1992	1319143	194.13	542895	3734236	2426181	6703312
1993	1505101	34.80	43480	765837	975561	1784878
1994	980609	18.09	6348	68632	83092	158072
1995	1624644	10.00	48500	688004	501969	1238473
1996	1626502	135.50	500000	4148319	4149988	8798307
1997	912894	82.24	17070	353649	632023	1002742
1998	502611	25.57	76355	690995		
1999	579412	41.35	25974			
2000	1340812					
2001	1492734					
2002	586530					

(a) enumerated at the Babine Fence, in millions of fish

Appendix 3. Escapement, total stock size and age composition data for Area 3 (Nass) sockeye salmon by calender year. Age 3 fish excluded (1)

		Total	Age Composition		
YEAR	Escapement	Stock	% age 4	% age 5	% age 6
1970	115503	266291	24.0	71.12	4.86
1971	247524	427054	30.6	66.60	2.84
1972	178716	428872	19.1	64.82	16.08
1973	284682	880049	43.6	53.78	2.65
1974	193703	581632	7.3	80.18	12.51
1975	70874	190650	22.7	72.54	4.71
1976	143405	412221	25.9	70.31	3.81
1977	400371	985238	29.4	65.91	4.72
1978	147716	496829	7.4	80.60	11.96
1979	212944	474666	24.8	71.43	3.78
1980	155515	417831	17.3	77.35	5.30
1981	255818	640323	57.1	41.53	1.33
1982	306070	859395	14.9	80.78	4.33
1983	185100	537499	30.4	61.07	8.53
1984	182450	505519	17.6	73.65	8.72
1985	361208	693433	59.8	34.16	6.09
1986	187251	595461	20.1	70.07	9.81
1987	184242	490348	14.4	79.10	6.52
1988	136760	359246	22.5	70.21	7.32
1989	112609	419346	44.0	47.15	8.84
1990	155472	405925	29.2	64.61	6.20
1991	269850	954805	34.5	60.03	5.43
1992	645964	1932687	51.8	43.88	4.32
1993	440740	2289869	39.1	56.64	4.23
1994	179262	706103	25.3	67.94	6.73
1995	237991	1188252	47.7	47.13	5.15
1996	219825	1005316	18.4	72.74	8.84
1997	237312	965622	29.7	61.49	8.86
1998	193810	570778	19.7	73.45	6.88
1999	217551	751716	31.8	61.54	6.69
2000	205111	633277	43.6	39.14	17.28
2001	168753	576975	22.1	53.77	24.18
2002	405473	1033347	update	update	update

(1) note: subject to revised run-reconstructions now being completed, 2002 data are prel.

Appendix 4. Escapements and brood year returns by age class for Area 3 (Nass) sockeye salmon. Age 3 fish and First nation catch excluded. (1)

Brood Year	Escapement	Smolts (a)	Adult Returns			Total
			Age 4	Age 5	Age 6	
1970	115503		42377	135003	15214	192594
1971	247524		42331	280427	45302	368060
1972	178716		103207	632261	58957	794425
1973	284682		281661	397341	17091	696094
1974	193703		36662	322839	19965	379466
1975	70874		112044	291152	8395	411590
1976	143405		65301	262814	35838	363953
1977	400371		361611	669259	41519	1072389
1978	147718		123350	297199	35650	456199
1979	212944		147896	300966	37820	486683
1980	155515		72031	212167	53623	337821
1981	255818		371180	383099	27217	781497
1982	306070		110010	330115	21526	461650
1983	185100		59985	206545	31952	298481
1984	182450		66094	170411	23516	260021
1985	361208		159034	245072	48059	452165
1986	187251		110700	531343	76667	718709
1987	184242		305657	779431	68882	1153970
1988	136760		920189	923040	37989	1881218
1989	112609		637838	383630	50247	1071715
1990	155472		143006	460122	88129	691257
1991	269850		465965	725211	85168	1276343
1992	645964		183687	590803	33328	807818
1993	440740		284908	355652	50869	691429
1994	179262		95198	467681	109890	672769
1995	237991		241414	248919	176868	667201
1996	219825		277110	393236	update	update
1997	237312		161233	update		
1998	193810		update			
1999	217551					
2000	205111					
2001	168753					
2002	405473					

(a) not available

(1) note: subject to revised run-reconstructions now being completed, 2002 data are prel.

Appendix 5: Skeena sockeye smolt and sibling model data and input parameters

		Data Set for Independent Variable					Brd yr=	1998	Brd yr=	1999	Model Parameters				
Model	equation	n	Mean(X)	SD(X)	Var(X)*(n-1	pr(age4)	Xi	(Xi-Mean)^2	Xi	(Xi-Mean)^2	a	b	Sy.x		
SMOLT	$\ln Y = a + b \ln X$	27	18.139	0.6764	11.893806	0.437	17.057	1.1708156	17.538	0.3616965	1.58175	0.72122	0.70806		
SIBLING															
Age 4	$\ln Y = a + b \ln X$	29	11.753	1.8302	29.716968	0.437			10.165	2.5229064	5.15182	0.73366	0.49819		
Age 5	$\ln Y = a + b \ln X$	28	13.774	0.88015	20.915973		13.446	0.1079862			3.38939	0.76833	0.52523		

Estimation of Mean and Standard Deviations for 2002 Forecast

	1997 Brd Yr Contributions			1998 Brd Yr Contributions			Combined Year Contributions			median(Y)
Model	E(lnY)		SD(lnY)	E(lnY)		SD(lnY)	E(lnY)		SD(lnY)	
SMOLT	13.884		0.7545	14.230		0.7315	13.991671		0.7533	(maximum) 1192516
SIBLING										
Age 4				12.599		0.4763	14.082265		0.5358	(maximum) 1295331